Advancing NEMS: Demand-side Management of Peak Loads

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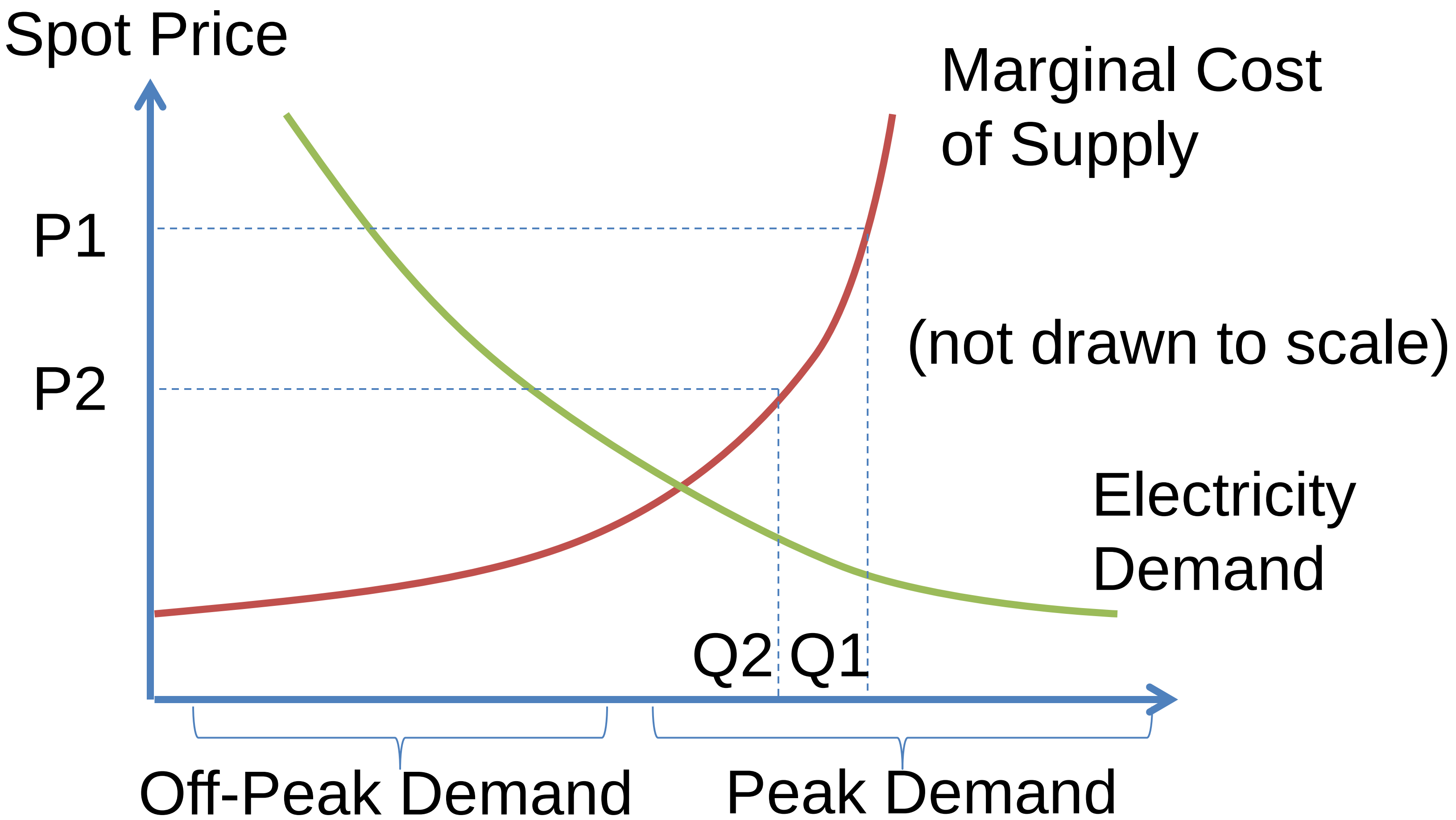
Impacts from Reducing Peak Load



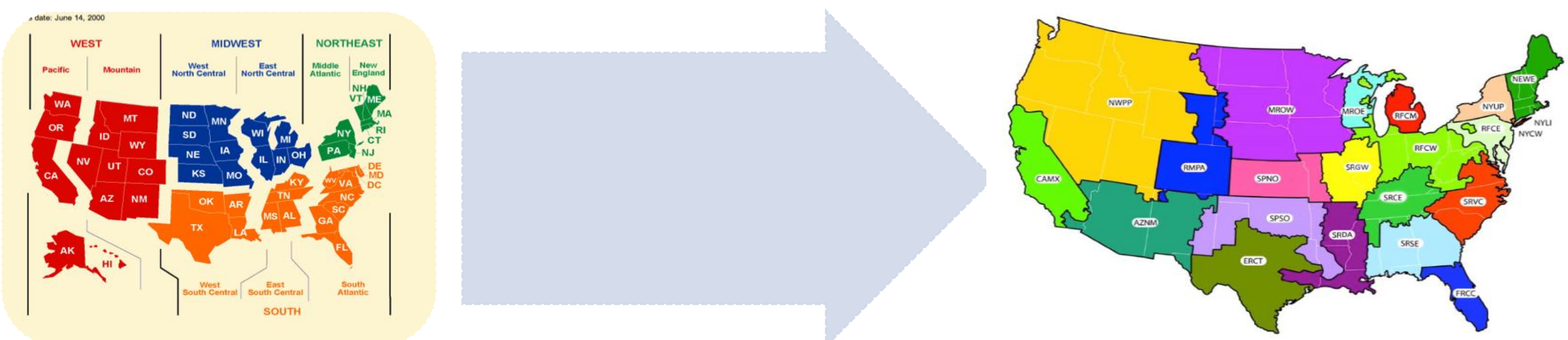
- Peak Load Management can reduce operating costs for utilities and save expenses for customers

Common Peak Load Management Programs

- Demand Response (DR)
  - Enables utility to induce peak load reductions at discretion
  - Differential hourly pricing (Dynamic and Time-of-Use)
  - Signaling & fixed rates (Interruptible load programs)
  - Remote control of end-use (Direct Load Control)
- Integrated Demand-side Management (I-DSM)
  - “New wave” of EE
  - Includes targeting peak-heavy end-uses for typical demand-side management EE programs and policies (e.g. subsidies, standards, new control technologies)

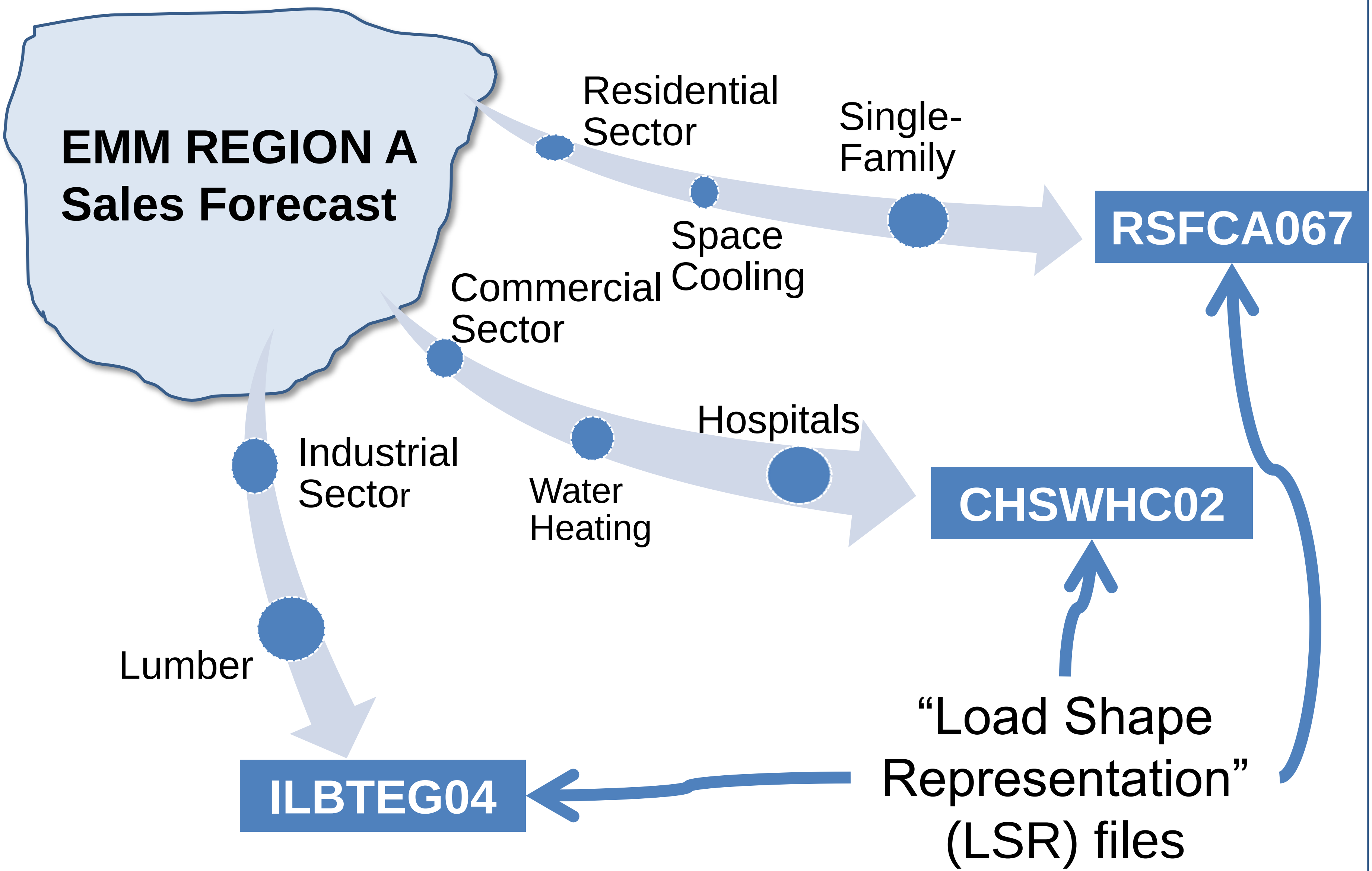
Peak Demand Modeling in NEMS

- The Electricity Market Module (EMM) constructs hourly load using a combination of demand module forecasts, end-use hourly load representations, and historical hourly load data
- First Step: Converting Census division sales forecasts to EMM region sales forecasts



- Sales forecasts are disaggregated by building type, end-use, and census division

EMM Regions Send Forecasts to LSRs



Sales First Go to Months (Weighted)

Sales for Hospital water heating in EMM Region A

All 9 other Months with their respective weights

March (weight=0.04)

February (weight=0.05)

January (weight=0.1)

Monthly weights are normalized so that monthly sales sums to annual sales

Sales Then Go to Day-Types (Weighted)

Sales for Hospital water heating in EMM Region A in January

Peak-Day: Once per Month (weight=0.2)

Weekday: applies to all weekdays in the month (weight=0.5)

Weekend: applies to all weekend-days in the month (weight=0.3)

Day-type weights are also normalized so that day-type sales sums to monthly sales

Sales Finally Go to Hours (load factors)

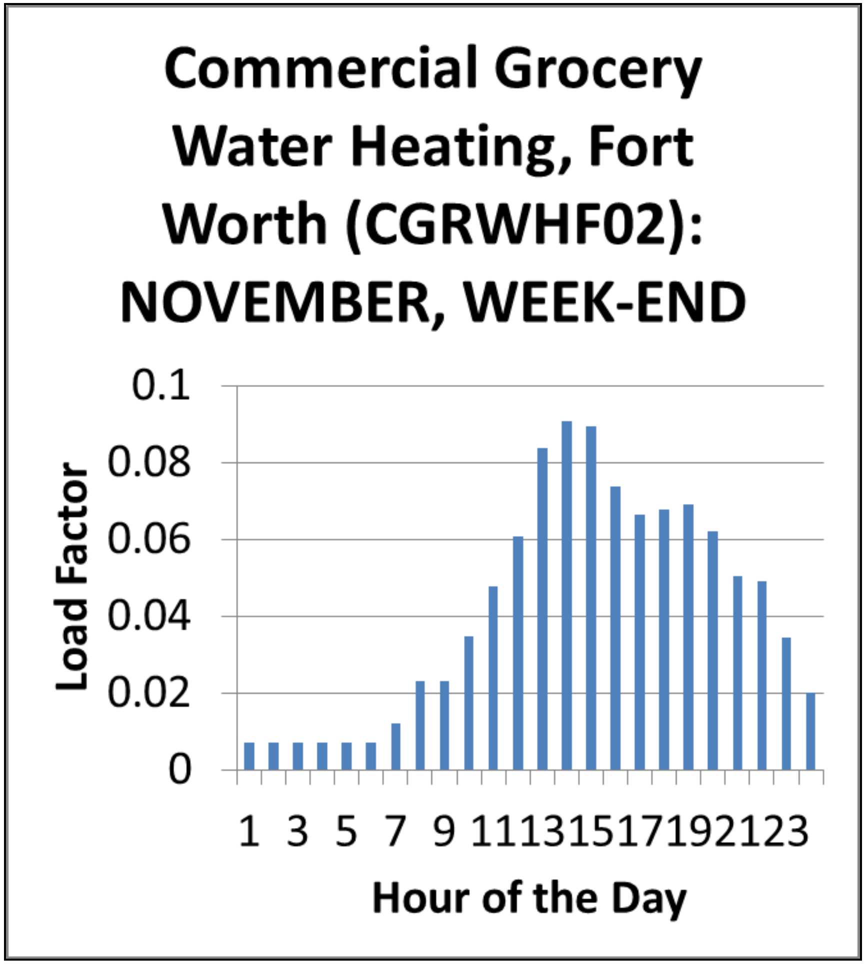
Sales for Hospital water heating in EMM Region A for a January Weekday

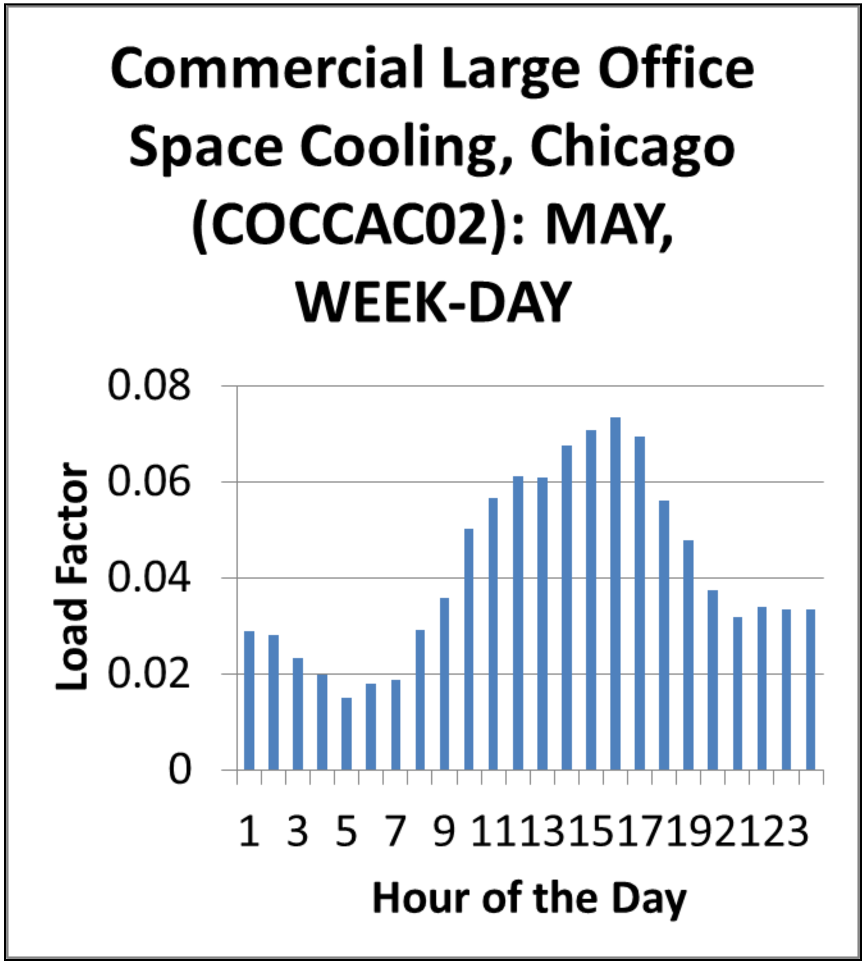
Hour 1 (load factor = 1.15)	…	**Hour 10 (load factor = 7.05)**	…	**Hour 18 (load factor = 5.4)**

“Load Factor” = portion of daily consumption in each hour

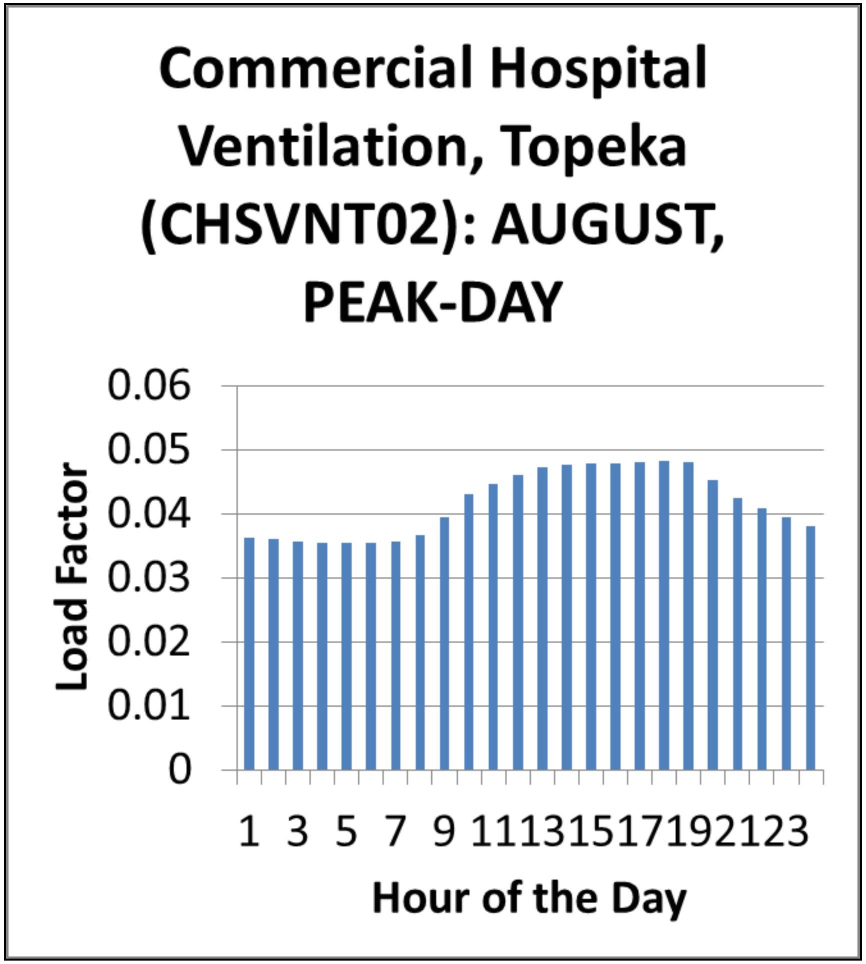
Hourly load factors are also normalized so that hourly sales sums to day-type sales

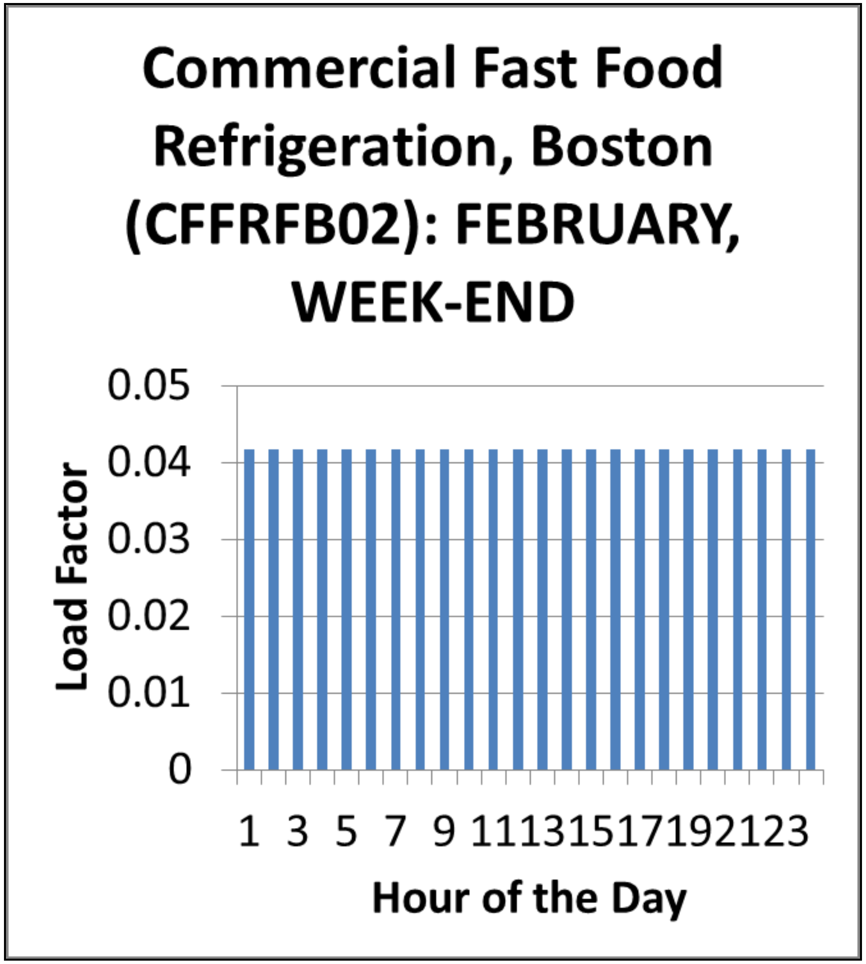
LSR Example 1: Peak-heavy End Uses





LSR Example 2: Peak-light End Uses

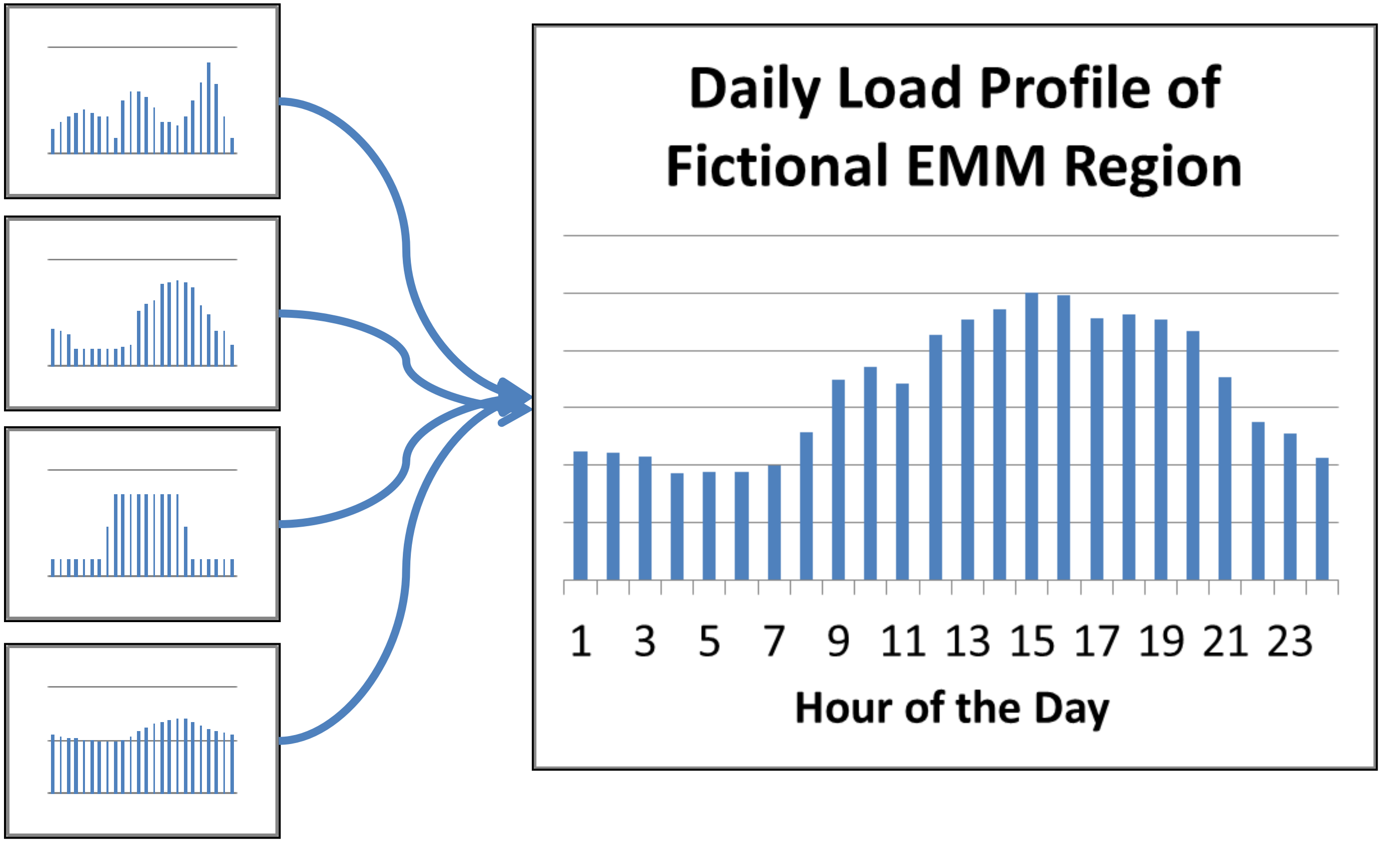




LSRs taken from EPRI’s RELOAD

- The RELOAD database contains electricity load profile shapes analogous to LSRs
  - ICF Resources, Inc. originally implemented RELOAD in NEMS
- The original source for the RELOAD database is the Electric Power Research Institute (EPRI)
  - Samples of end-use data from various cities around the U.S.
  - Certain cities’ data were chosen to represent EMM regions
- EIA has implemented suggested improvements to the RELOAD database made by OnLocation in 2001 and LBNL in the early 2000’s

EMM Region Profiles are sums of LSRs



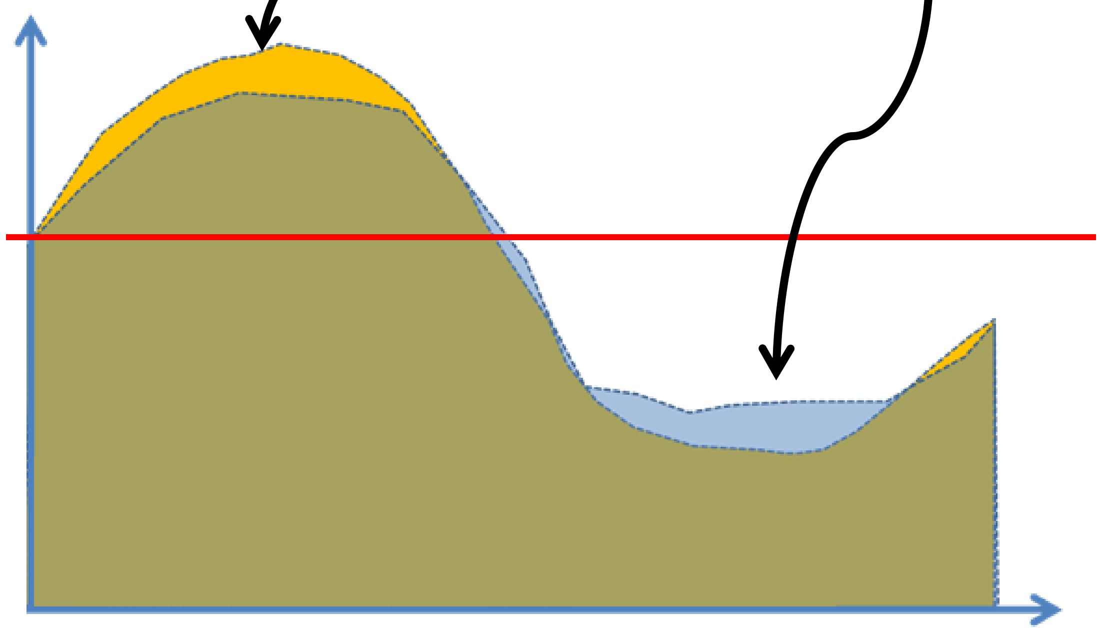
An example of a Regional "bottom-up" profile

- The regional bottom-up profiles are adjusted using historical load profile data from NERC

Demand Response in NEMS

- Demand Storage is a capacity technology used by NEMS to emulate DR and is similar to pumped hydro

$$\textbf{STFAC} = \frac{\text{Compensating Off-Peak Generation}}{\text{Peak Load Reduction}}$$

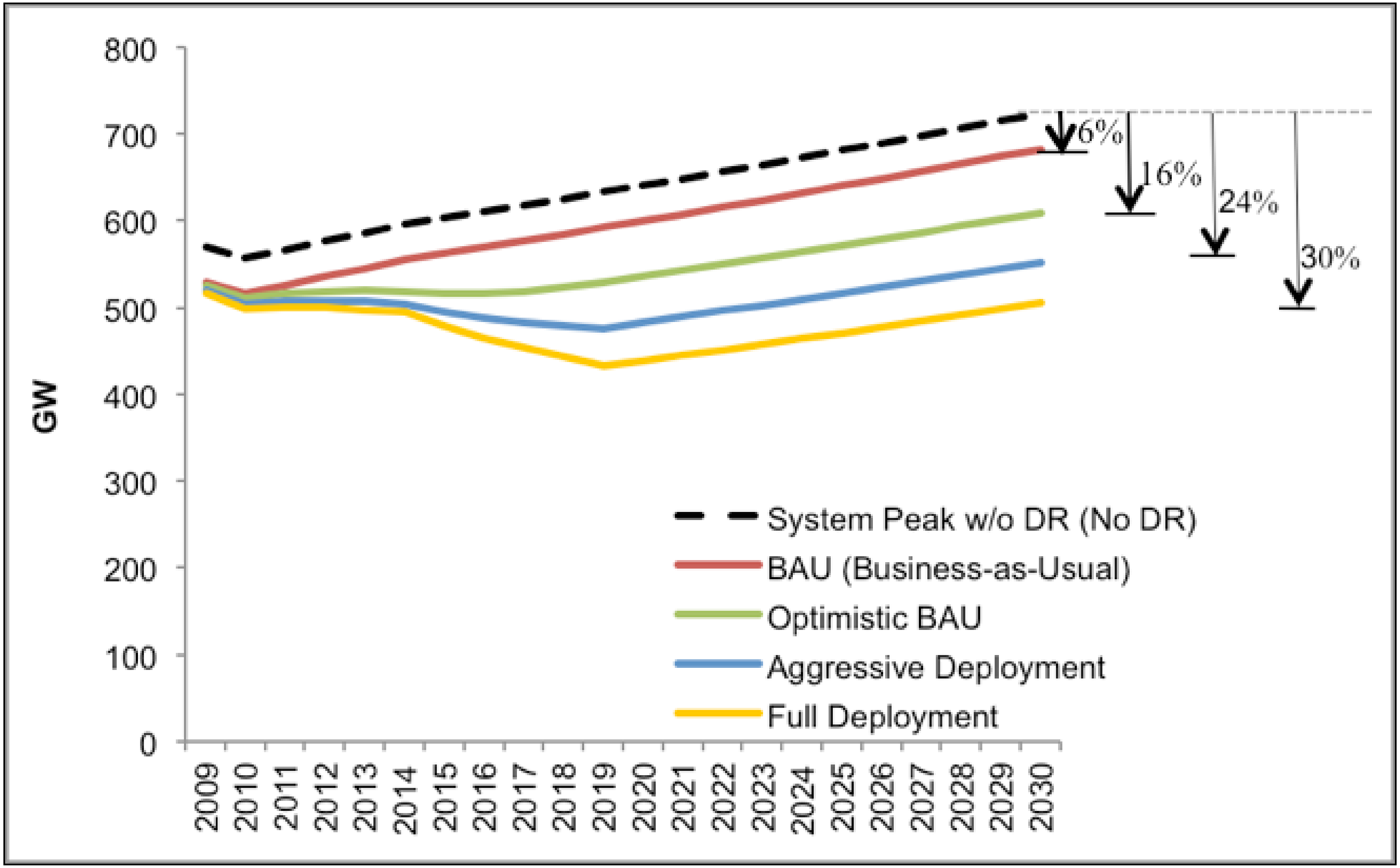


Users control Demand Storage though two variables: STFAC and STLIM

STLIM: Demand storage cannot be dispatched to meet demand below this level

Capital cost = $292.26/KW, V-O&M cost = $0.19/MWh, F-O&M cost = $0.01/MWh (2011 dollars)

DR Potential Estimates for EI (STLIM)

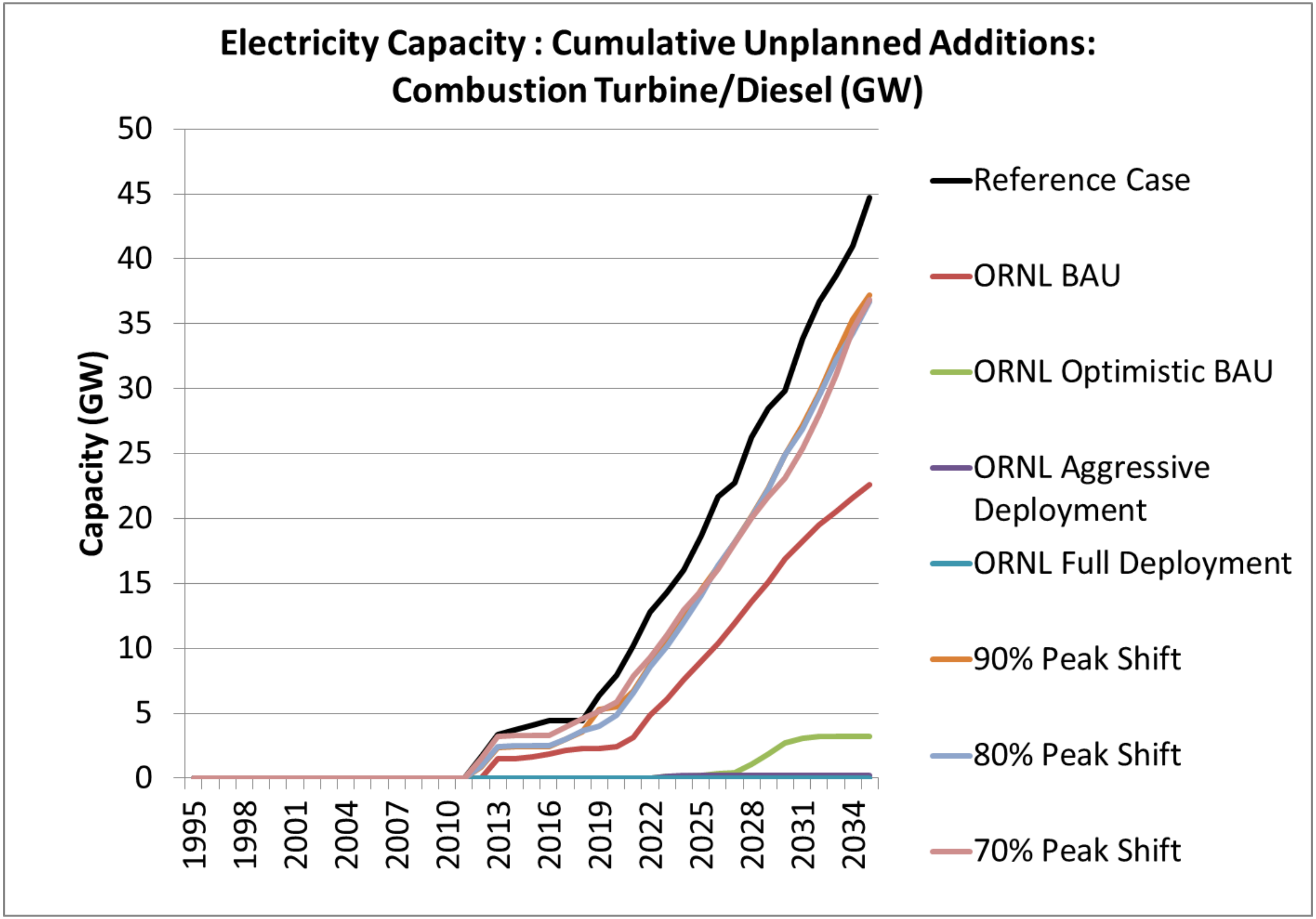


Source: Baek, Y. et al (2012) Eastern interconnection Demand Response Potential. Oak Ridge National Laboratory, ORNL/TM-2012/303

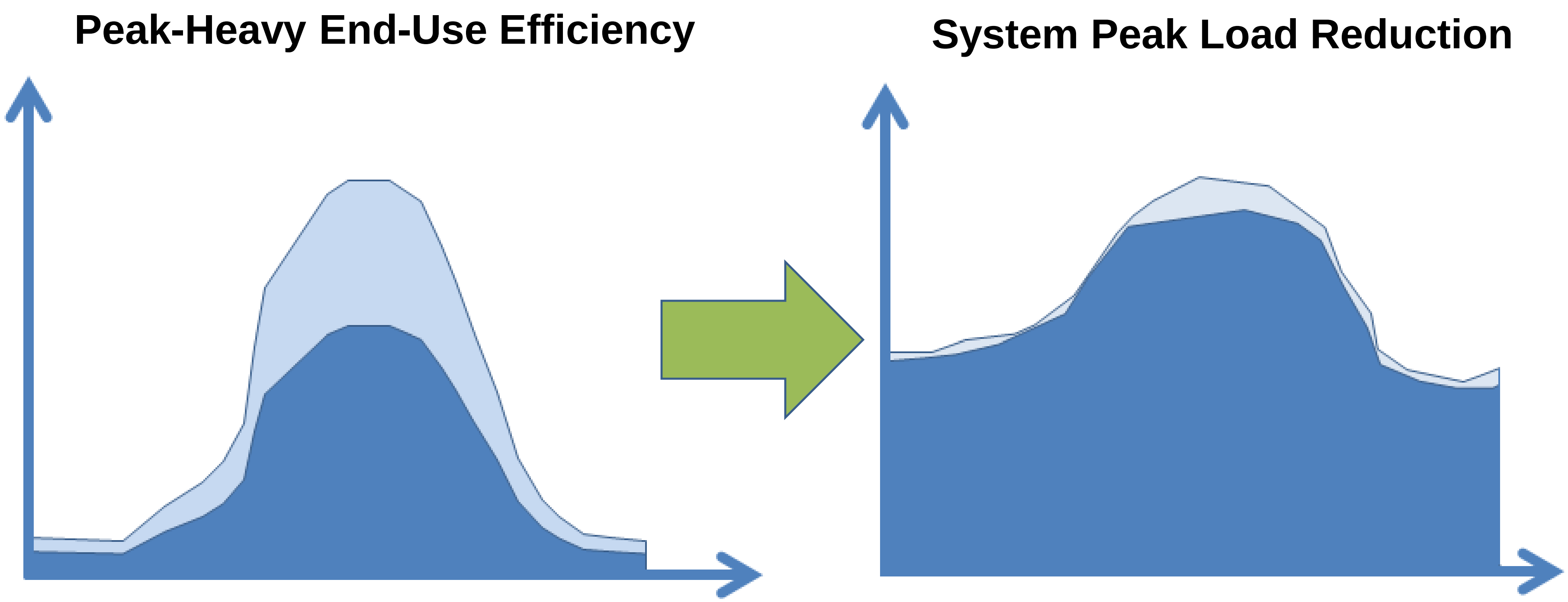
Demand Storage Sensitivities

- To understand and illustrate the relative impact of the variables for controlling demand storage, seven sensitivity runs were performed
- First Set – STLIM adjustments to ORNL estimates
  - "ORNL BAU:" DR can meet 6% of Peak Load by 2035
  - "ORNL Optimistic BAU:" 16% of Peak Load by 2035
  - "ORNL Aggressive Deployment:" 24% by 2035
  - "ORNL Full Deployment:" 30% by 2035
- Second Set – STFAC adjustments
  - "90% Peak Shift:" 90% of peak load reductions through demand storage are shifted to off-peak periods
  - "80% Peak Shift" and "70% Peak Shift" follow suit

Demands Storage Sensitivity Results



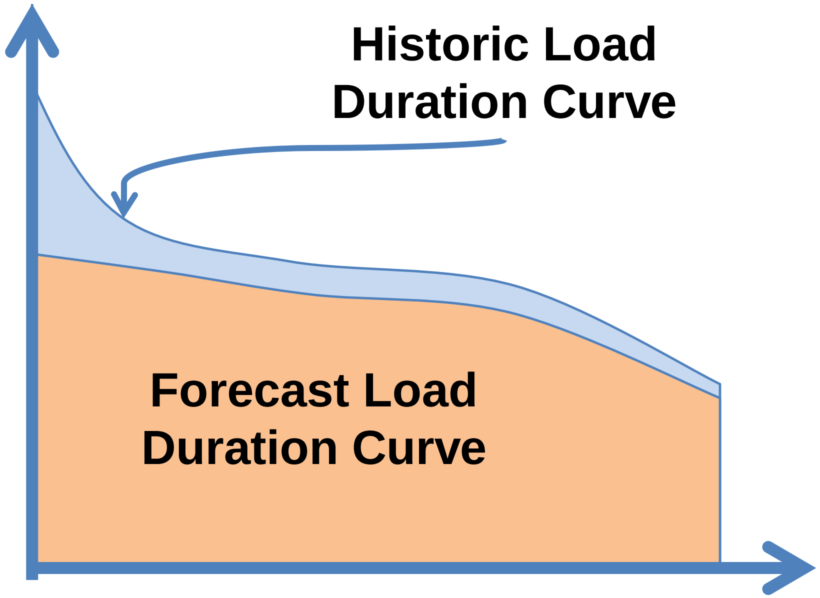
Integrated DSM: Peak-Load-Targeted EE



- I-DSM can be modeled in NEMS through subsidies, standards, and other EE policies targeted by the user toward peak-heavy end-uses
  - Space cooling and water heating are good examples

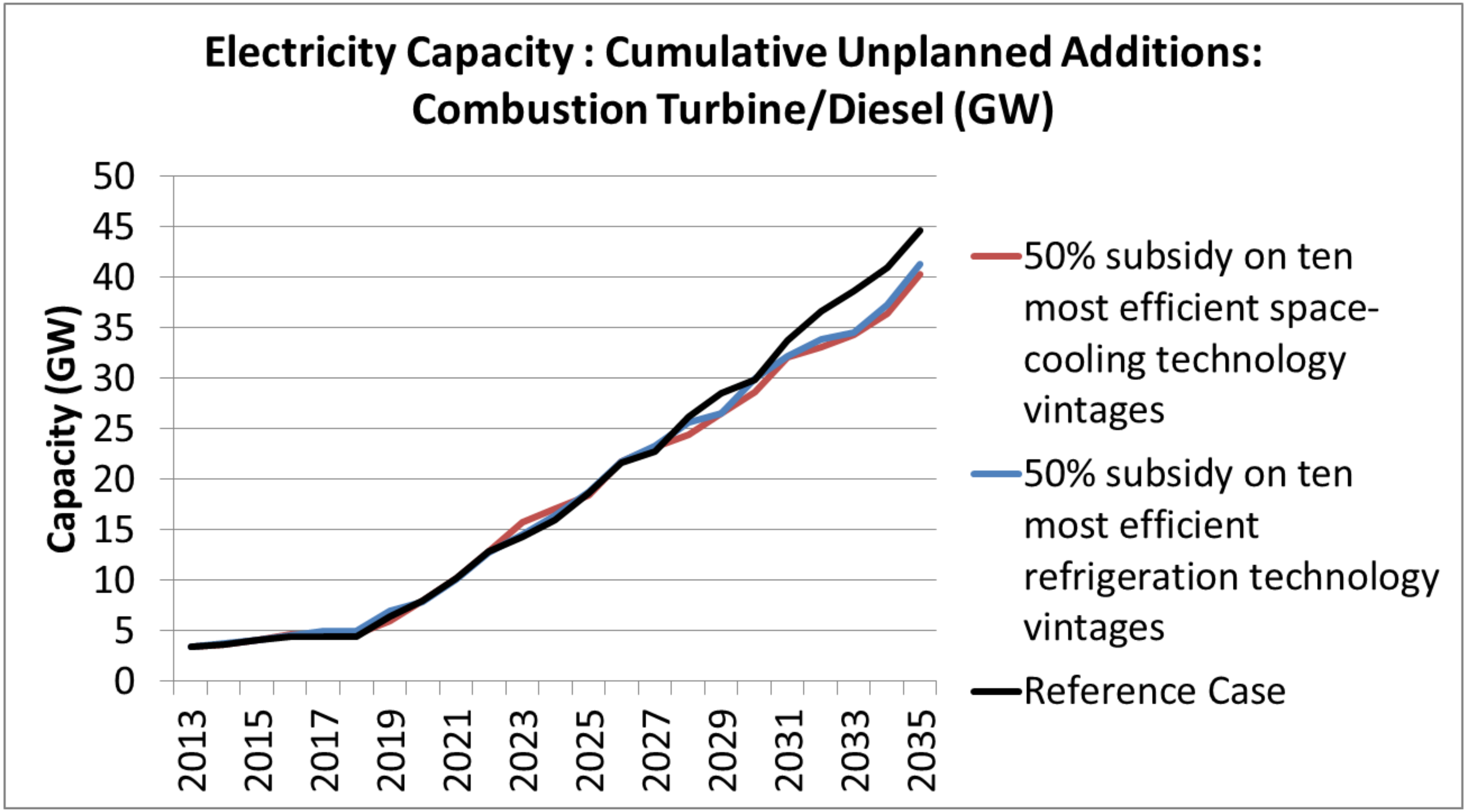
Load Adjustments and Modeling I-DSM

- Load duration curve forecast by NEMS is corrected using historical load data from NERC
  - The correction can have special effects upon peak load



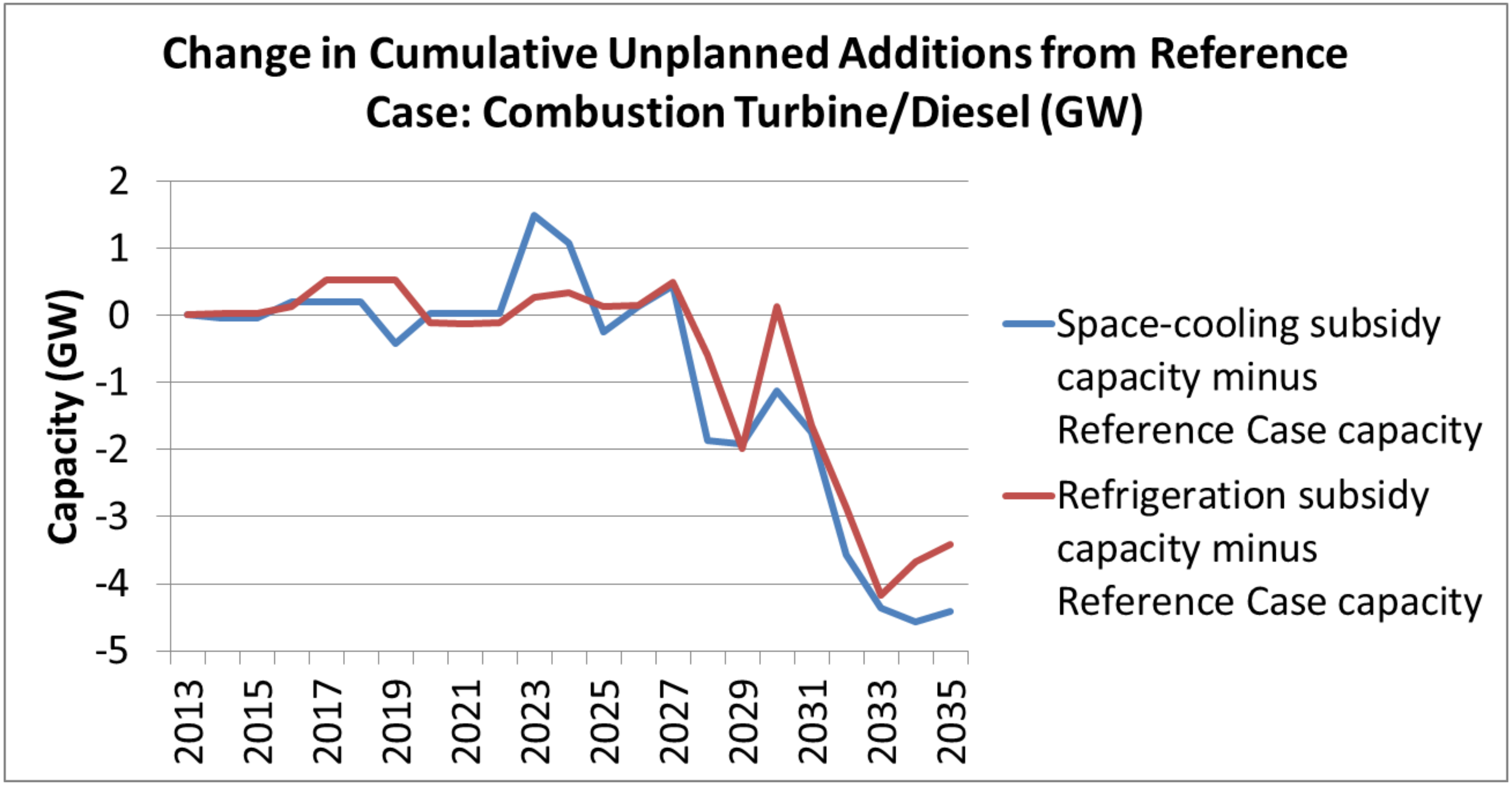
- Lawrence Berkeley National Laboratory discovered a load-adjusting "squelch factor"
  - Scales current-year forecast peak load to base-year values
  - Responsible for minor shifts in peak load values
- The results of the adjustment are important
  - affect capacity choice and dispatch decisions in EMM

I-DSM Sensitivity Results



- Two I-DSM sensitivities were performed: subsidies of space-cooling and refrigeration technologies

I-DSM Sensitivity Results



- Unusual similarity between space-cooling and refrigeration impacts upon peak generation…

Opportunities to Advance PLM in NEMS

- Standard outputs in NEMS for PLM impacts?
  - Standard outputs of hourly load in NEMS?
- Standard outputs for Demand Storage capacity?
- Differentiating Demand Storage along DR program categories?
  - Pricing programs?
  - Direct-load-control programs?
  - Interruptible rate programs?
- Ensuring that adjustments to hourly load modeling do not cause impacts of PLM to be mis-represented?

Thoughts from the Audience

- *What do you see as the major improvements needed or gaps in capability for modeling Peak Load Management through DSM?*
- How can we balance the need for historical accuracy with the need for sensitivity to user input in load profile modeling?
- What aspects of demand response are well-captured by demand storage? What features are not?
- How might NEMS users make use of hourly load profile and LDC outputs from NEMS? What are the challenges with presenting such outputs?
- What other aspects of Peak Load Management are not represented or are under-represented in NEMS?

Contact Information

The research team welcomes further comments and questions.

Please contact

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Appendix A: LDC Adjustments

- EIA developed a method to adjust the bottom-up profiles into closer alignment with historical profiles
- The “Delta Approach” adjusts bottom-up load by the difference between forecast-year energy consumption and historic-reference-year energy consumption
    - To accommodate historic data on hourly load, the EMM adds an extra end-use and shapes its hourly load to reflect historical data
    - The hourly load of this end-use is compared to the hourly load from the bottom-up approach, and the bottom-up calculations are adjusted to reduce differences from historic data

Delta Approach Equation

- Equation for the Delta Approach
- ( ) ( )
  ( )
- Where
  - SYSLOAD(H) = load at hour H used in EMM's load profile
  - $DistLo_S(H)$ = load factor at hour H from historical profile data
  - SystemLoad = "base year total system load"
  - NUSES = total number of end-uses
  - $DistLo_e(H)$ = load at hour H for end-use e from LSR approach
  - $Load_{1e}$ = "current year load for end-use e"
  - BaseYrLd(e,R) = "base year load for end-use e in region R"

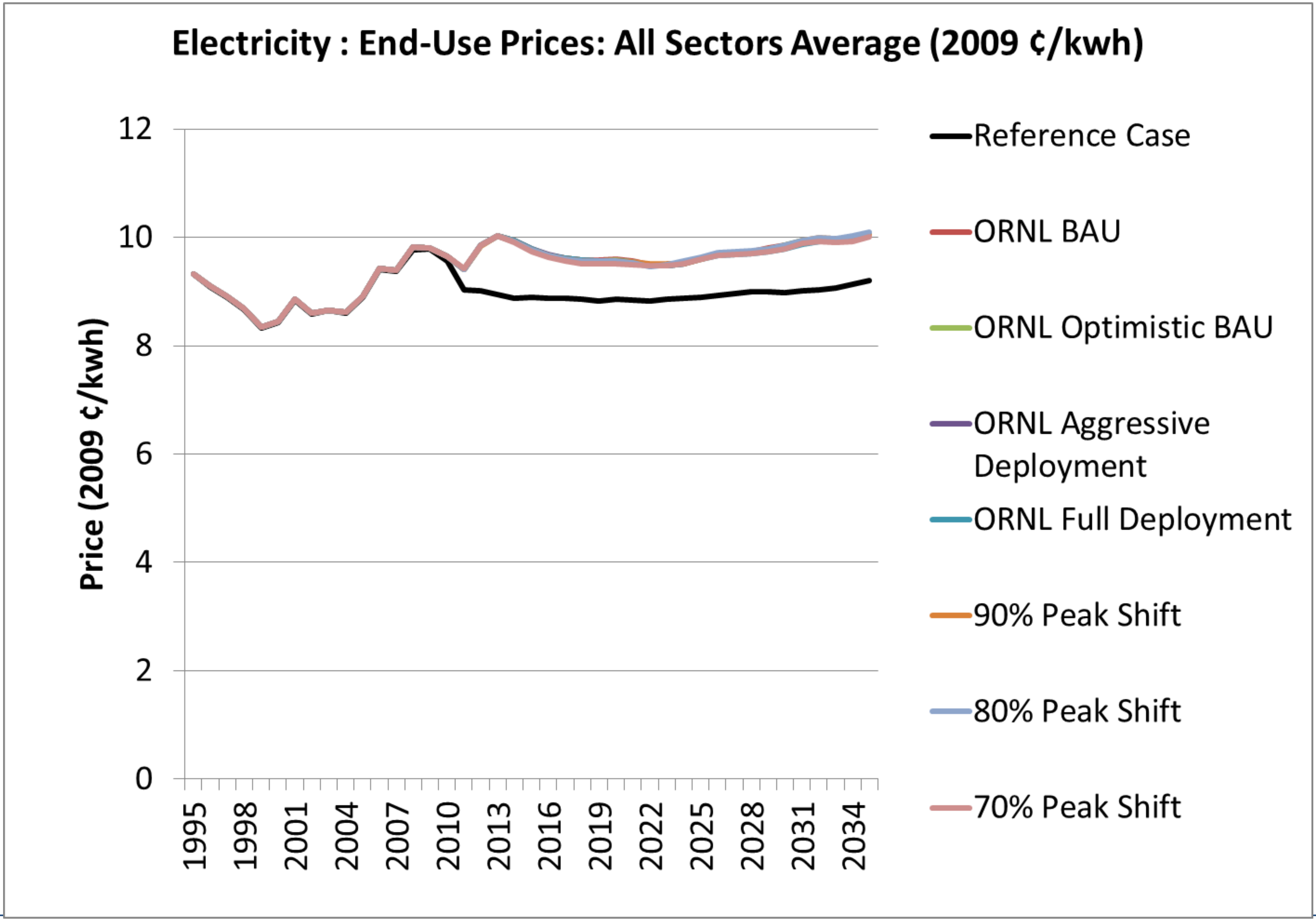
Appendix B: FERC Model Comparison

- The National Assessment of Demand Response model ("NADR") and Demand Response Impact Value Estimation model ("DRIVE") were developed by the Federal Energy Regulatory Commission (FERC) in response to the EISA 2007 DR directive
  - NADR was constructed to forecast the potential peak load reduction available in states and regions of the US through DR programs under a variety of assumptions
  - DRIVE was constructed to estimate the impacts upon capacity, emissions, and system costs of given levels of DR peak load reduction
  - NADR thus supplies inputs to DRIVE

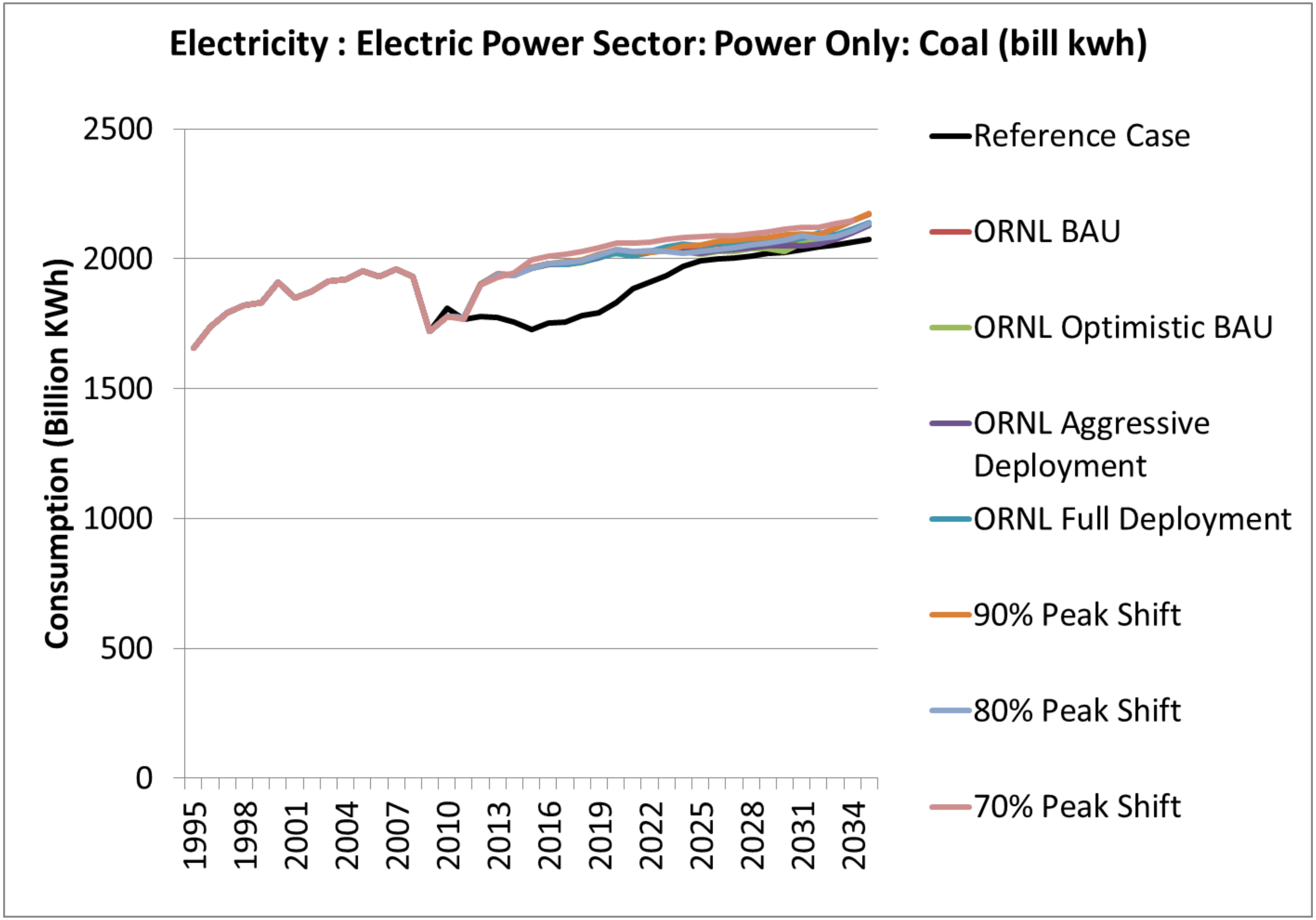
NADR and DRIVE vs. NEMS

- NADR is a complex estimation of what is specified in NEMS as an input – namely, the fraction of peak block loads that can be met by Demand Storage
  - NADR estimates absolute values of peak demand reduction, which can be approximated in NEMS via the STLIM input
  - NADR provides a good foundation for specifying STLIM, but requires its own input variables and assumptions
- DRIVE serves the same function as NEMS' EMM ECP and EFD sub-modules – estimating planning and operating decisions of the electricity system
  - ECP and EFD are informed by much wider array of modules, such as Coal Supply and Natural Gas supply modules

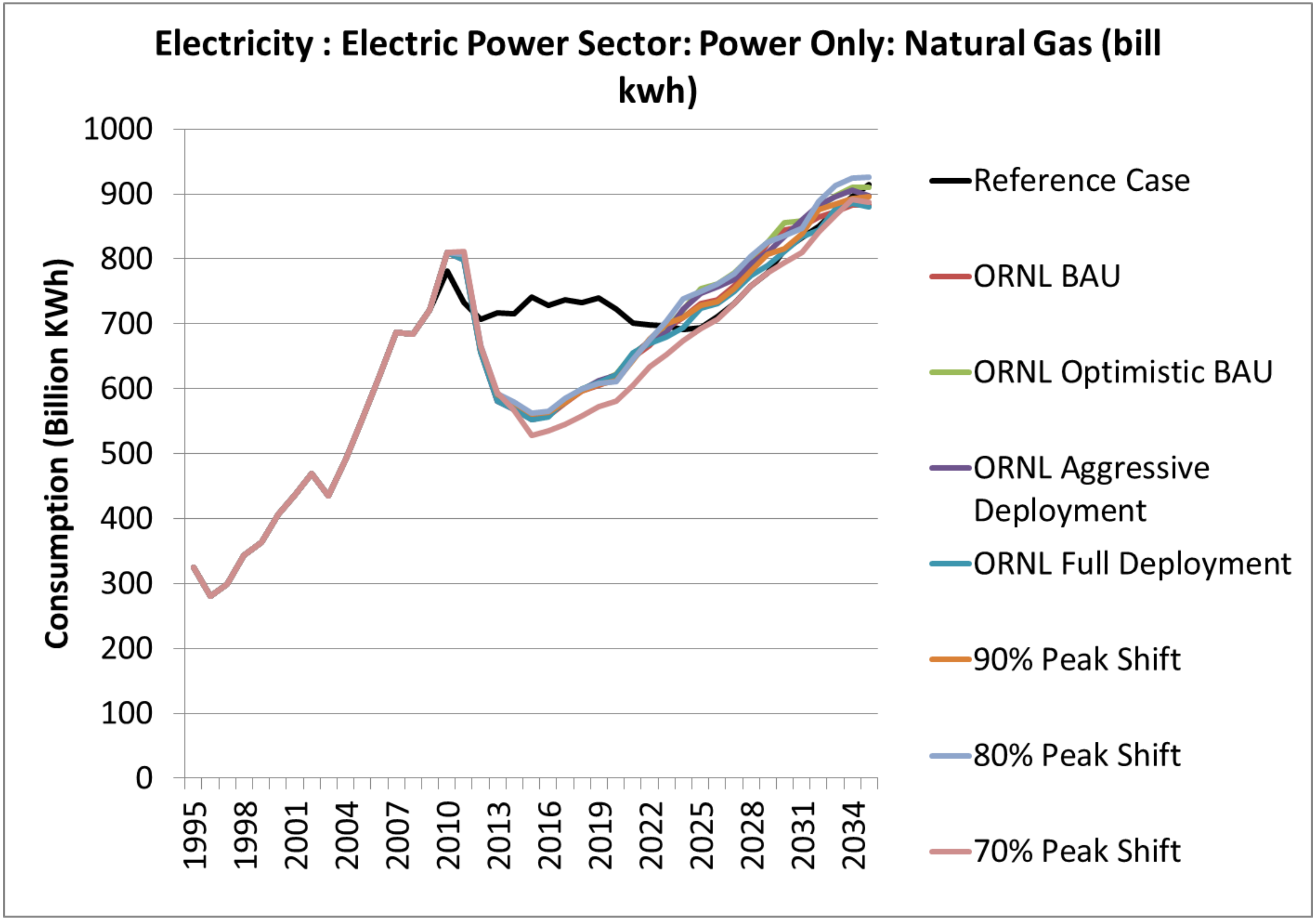
Sensitivity Results: Prices



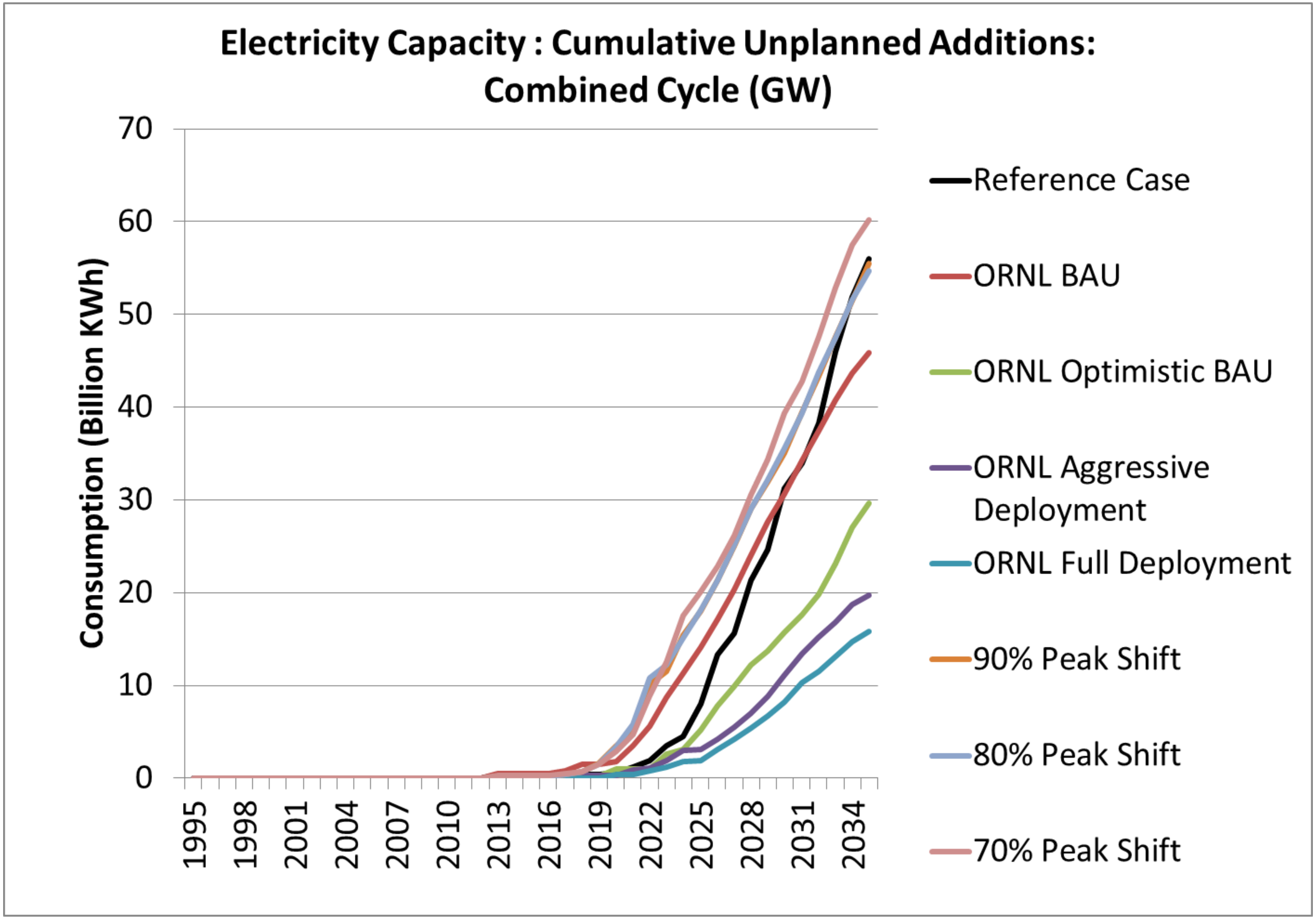
Sensitivity Results: Coal Consumption



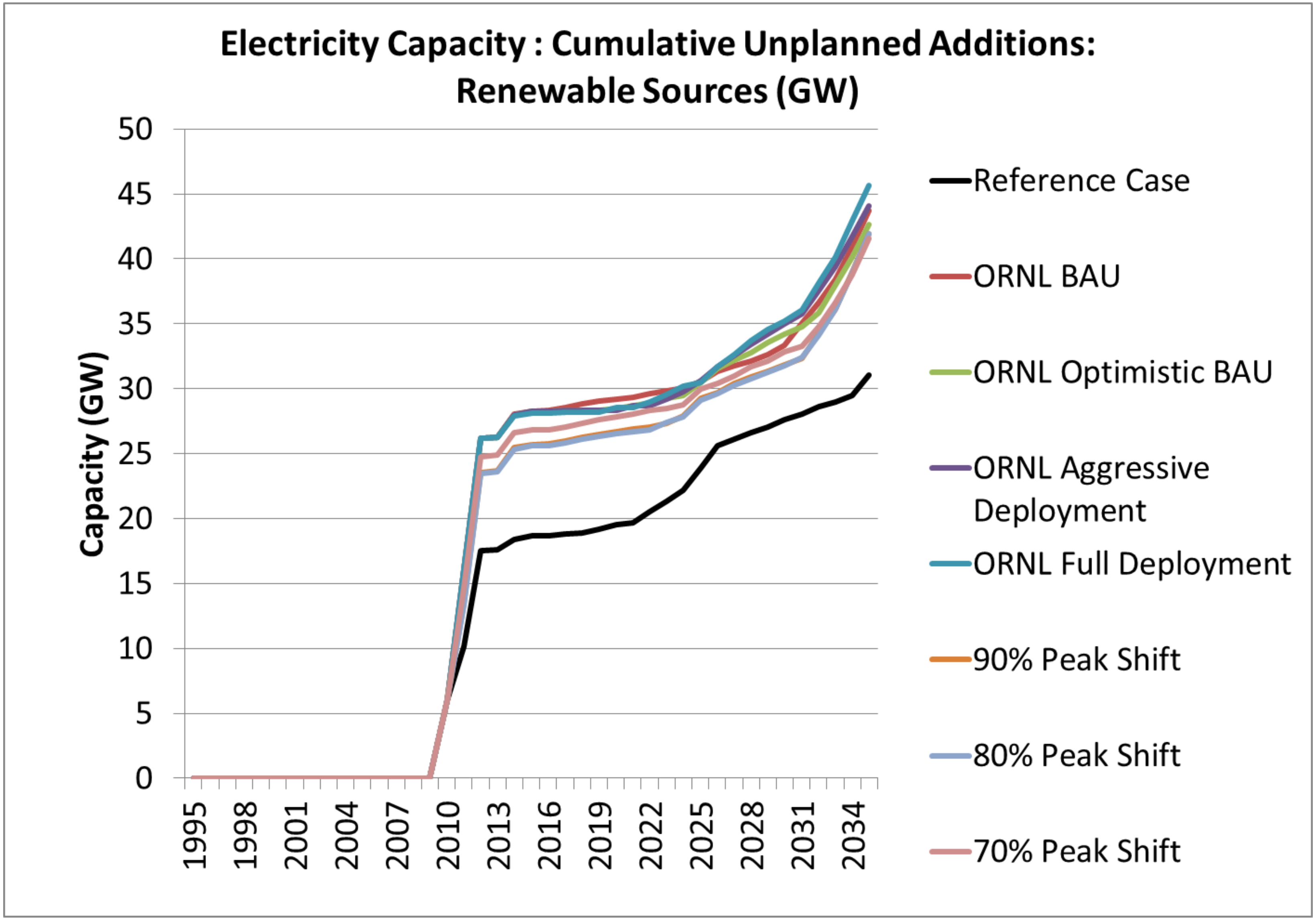
Sensitivity Results: Natural Gas kWh



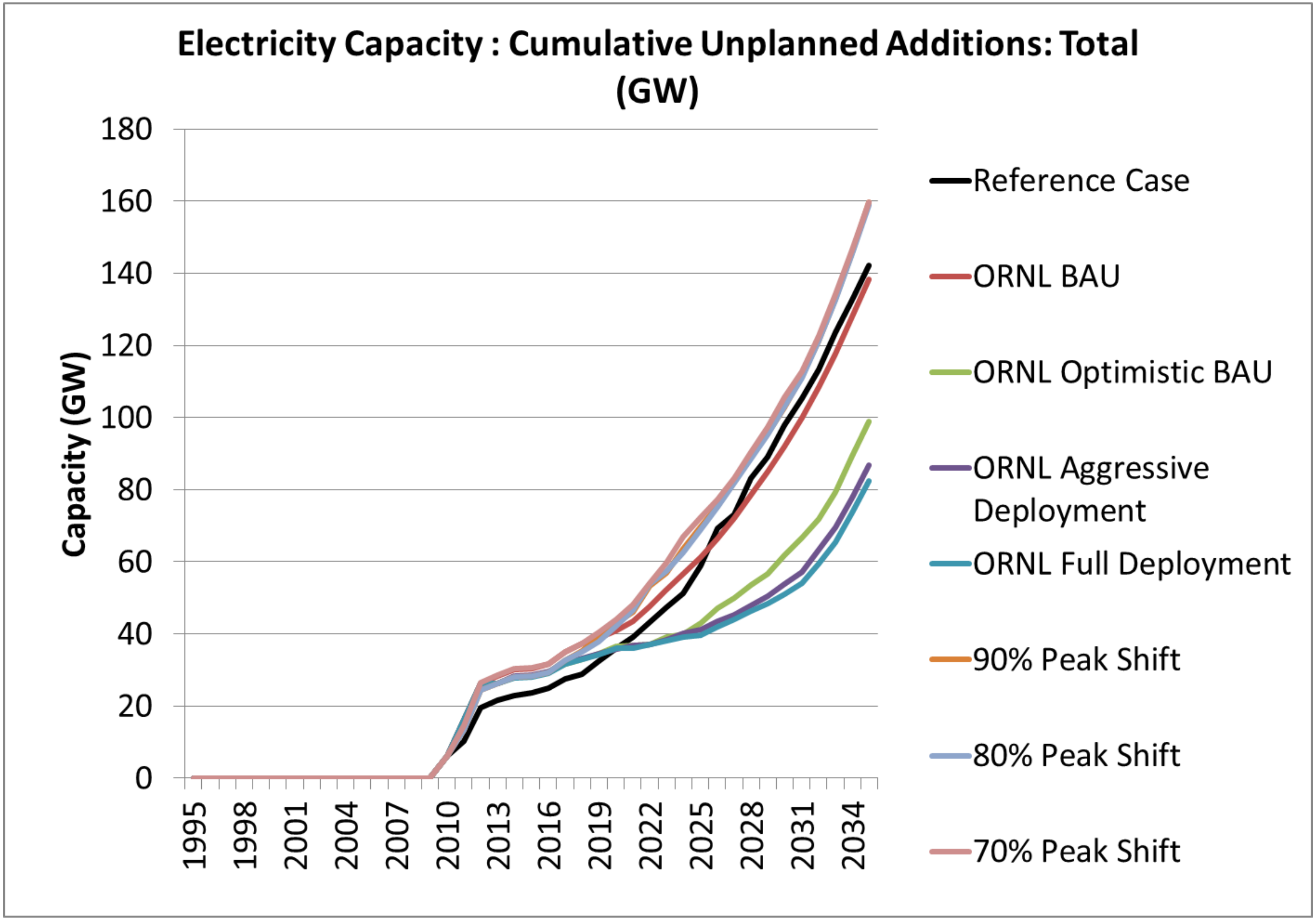
Sensitivity Results: Combined Cycle



Sensitivity Results: Renewables



Sensitivity Results: Total Added Capacity



I-DSM: Technologies Subsidized

Year of Introduction	Year of Exit	Technology Name
2003	2052	comm_GSHP-cool 2007-10 high
2008	2016	comm_GSHP-cool 2007-10 high 10% ITC w MACRS
2020	2052	comm_GSHP-cool 2020 high
2003	2052	centrifugal_chiller 2007 high
2010	2052	centrifugal_chiller 2010 high
2020	2052	centrifugal_chiller 2020 high
2020	2052	centrifugal_chiller 2020 typical
2003	2052	centrifugal_chiller 2007 mid range
2010	2052	res_type_central_AC 2010 high
2020	2052	res_type_central_AC 2020 high

I-DSM: Technologies Subsidized

Year of Introduction	Year of Exit	Technology Name
2004	2050	Supermkt_condenser 2008 high
2010	2050	Supermkt_condenser 2010 high
2020	2050	Supermkt_condenser 2020 high
2004	2050	Supermkt_condenser 2008 typical
2010	2050	Supermkt_condenser 2010 typical
2020	2050	Supermkt_condenser 2020 typical
2003	2050	Supermkt_condenser installed base
2004	2050	Supermkt_condenser 2008 low
2009	2050	Walk-In_refrig 2010 high
2020	2050	Walk-In_refrig 2020 high